

# YEAR-TO-YEAR DYNAMICS OF TROPHIC LINKS OF THE MAIN COMMERCIAL FISHES IN THE BARENTS SEA AS INDICATING THE STATE OF ECOSYSTEM

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The main goals are to investigate the effect of climate variation and fishery on structural changes in the Barents Sea ecosystem, and also influence of these factors on commercial fish populations



# MATERIALS

There were our own, archive and literature data of feeding, stock dynamic, distribution and fatness of cod and capelin since 70s till nowadays used in this paper

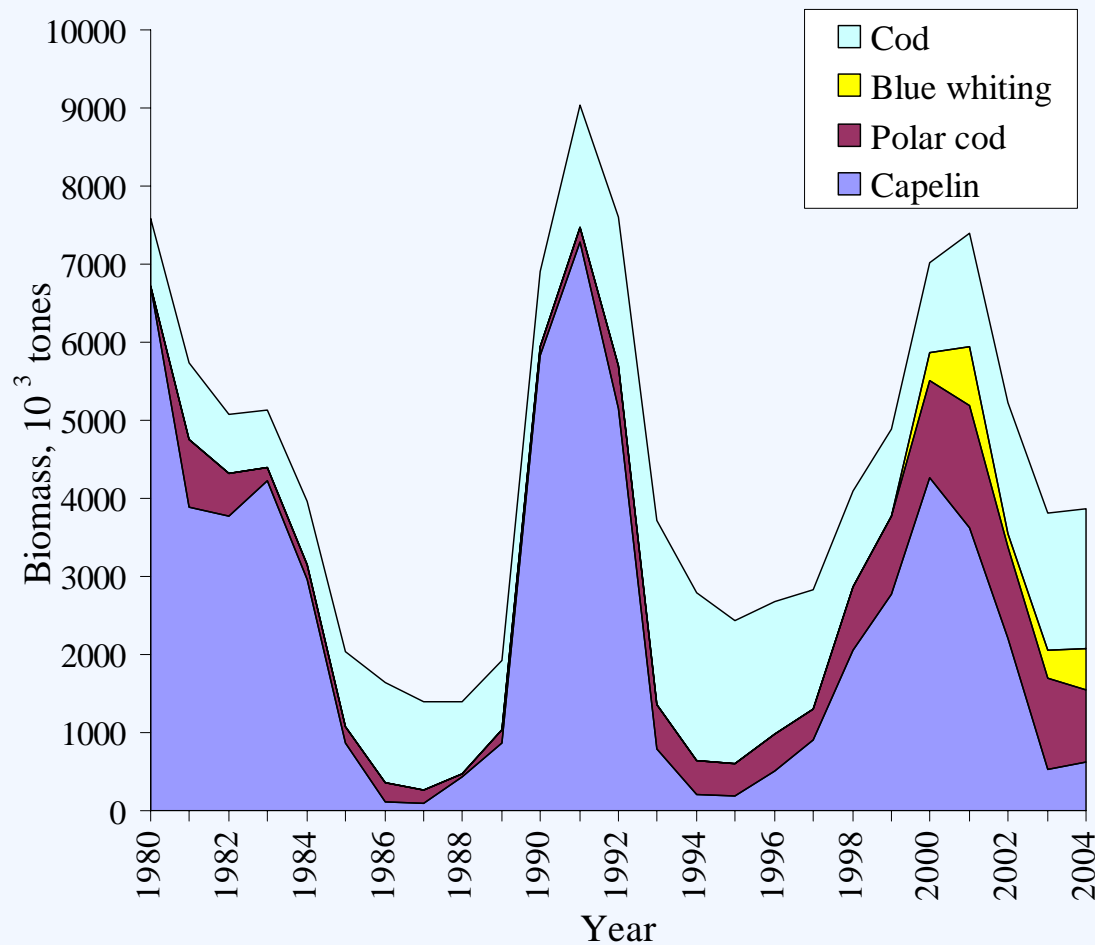


# INTRODUCTION

The functioning of the Barents Sea ecosystem is based on the energy transformation in phytoplankton-zooplankton-pelagic fishes-cod trophic chain. Despite a highly euryphagous character, cod feeding is connected with numerous traditional fishes – capelin, herring, polar cod, as well as juvenile fish and crustaceans (euphausiids, hyperiids) forming seasonal concentrations. The effect on commercial fish stocks is also great. The impact of these factors is often superimposed accompanying by the change of dominating species in cod feeding: they were polar cod in the 1920s, capelin or herring in the 1930s, capelin in the 1970-80s.



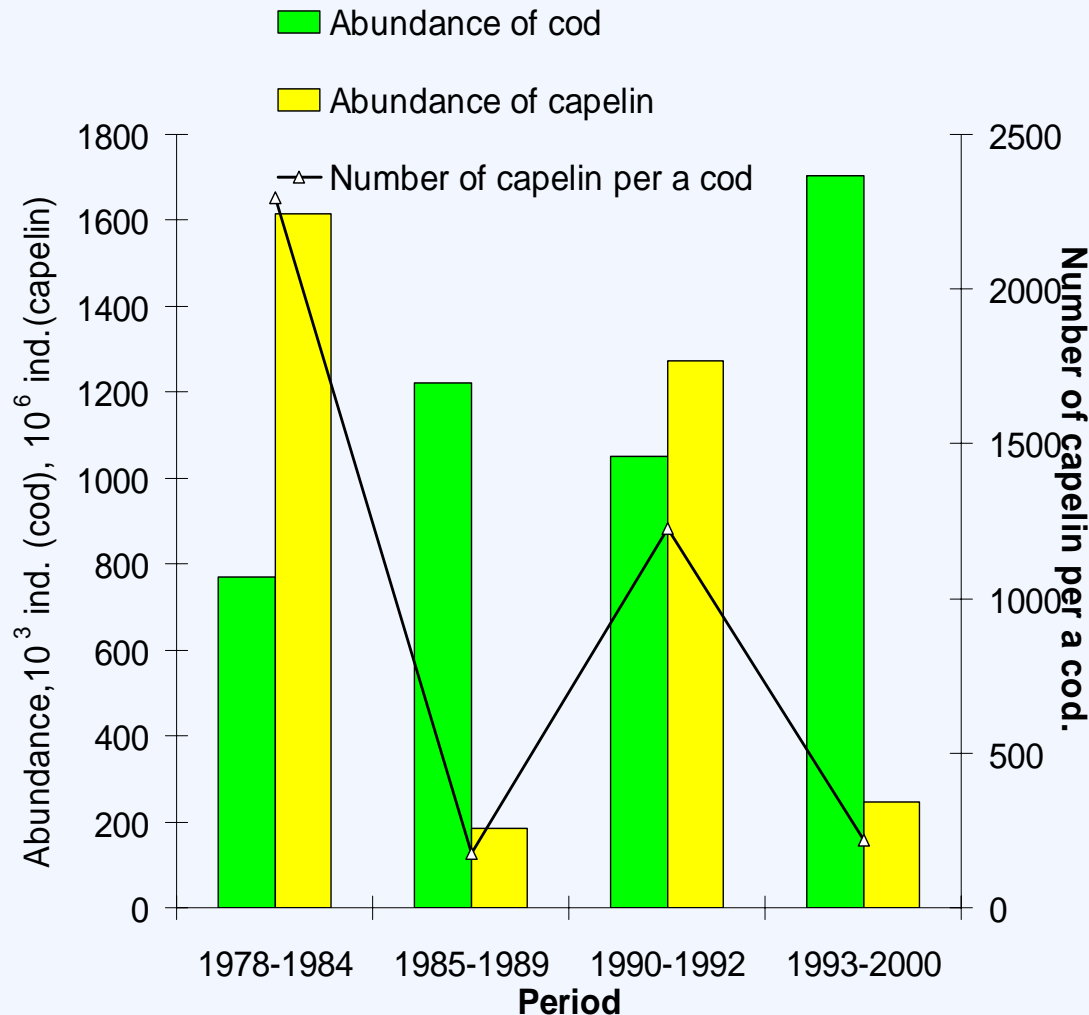
# Stocks dynamics of cod, capelin, polar cod and blue whiting in 1980-2004.



During the last twenty years, in the Barents Sea, the significant fluctuations of pelagic fish stocks were registered. They were typical, mainly, for capelin



# Stocks dynamics and cod supply by capelin in different time periods in 1978-2000.



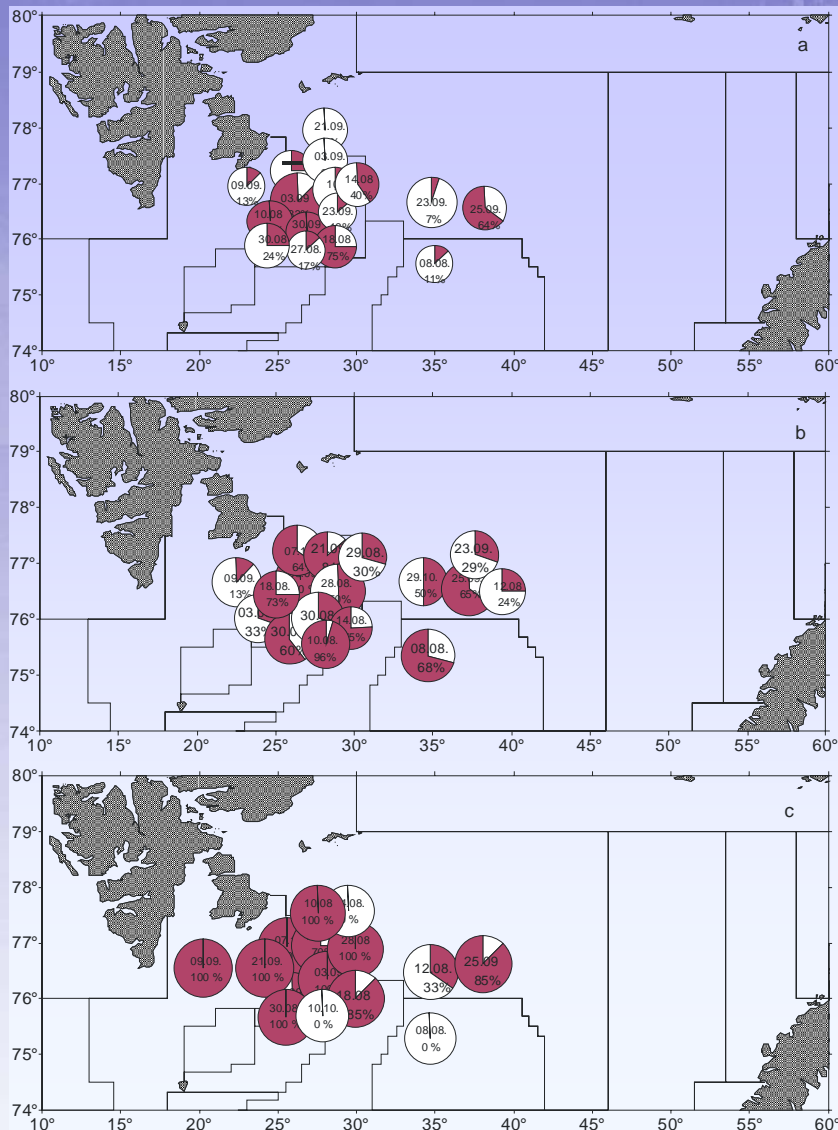
According to trends of capelin stocks, a conditional index of cod food supply (the number of capelin per a cod) reaching 2,500-3,400 ind.

in the early 1980s have not exceeded 200-300 ind. recently and was minimal in 1995





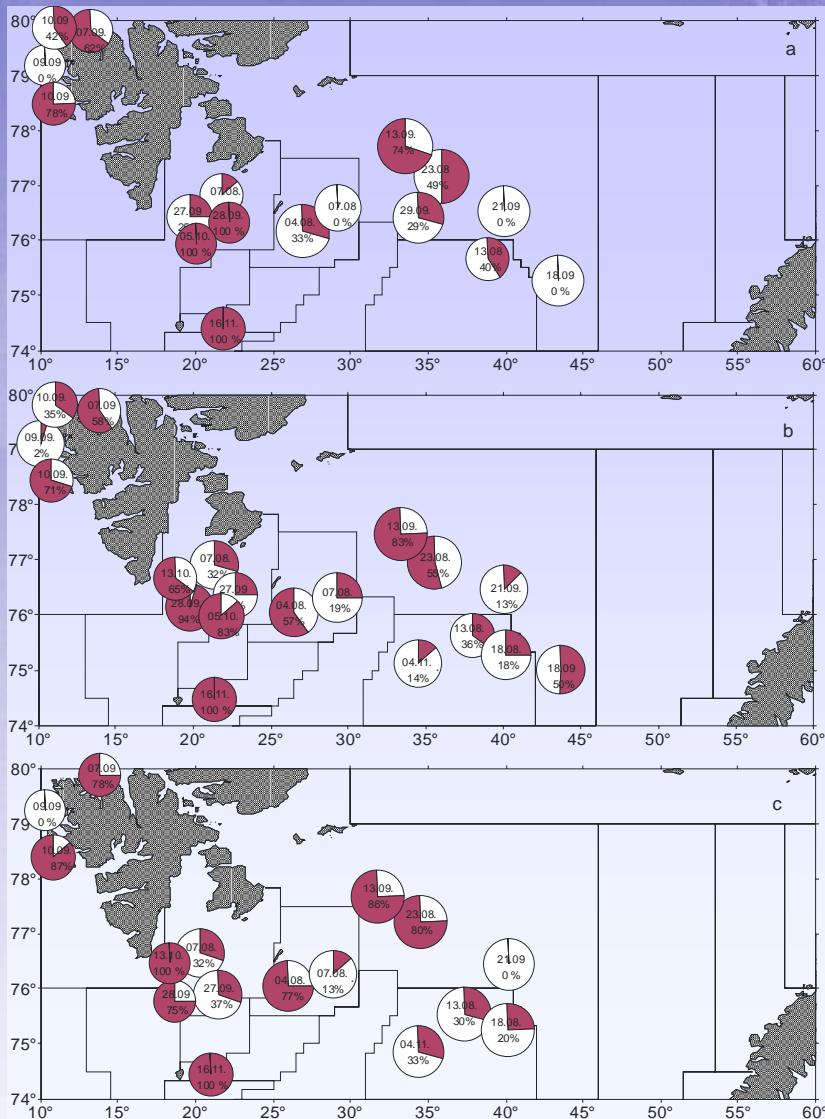
# Frequency of occurrence (%) euphausiids in stomachs of capelin by age 2 (a), 3 (b) и 4 (c) in August-October 1979



In anomalous 1979, feeding on euphausiids was the most prolonged in the Hope Area. To the north of 77°N, capelin did not feed on euphausiids and started to consume copepods



# Frequency of occurrence (%) euphausiids in stomachs of capelin by age 2 (a), 3 (b) и 4 (c) in August-November 1980

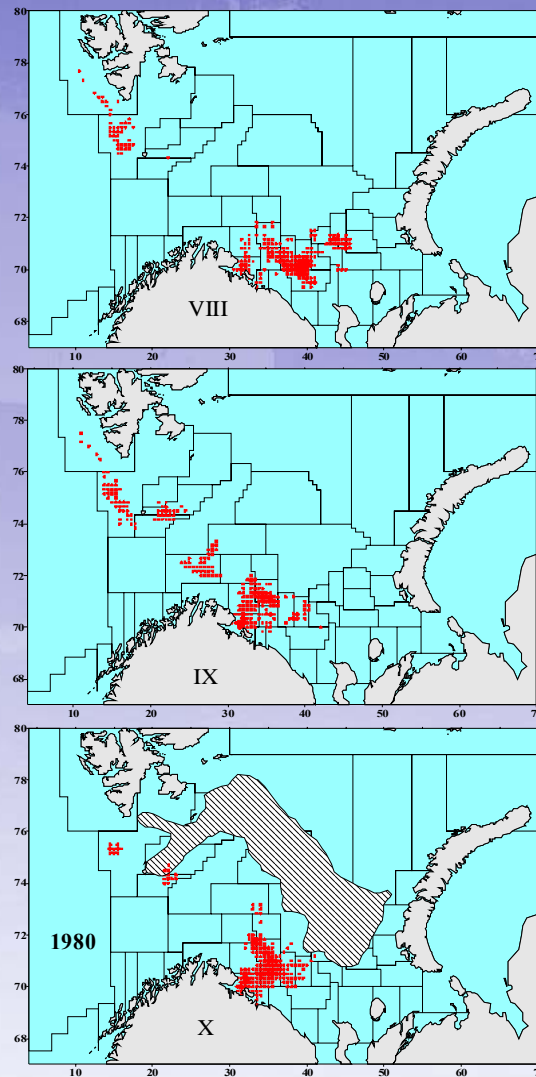
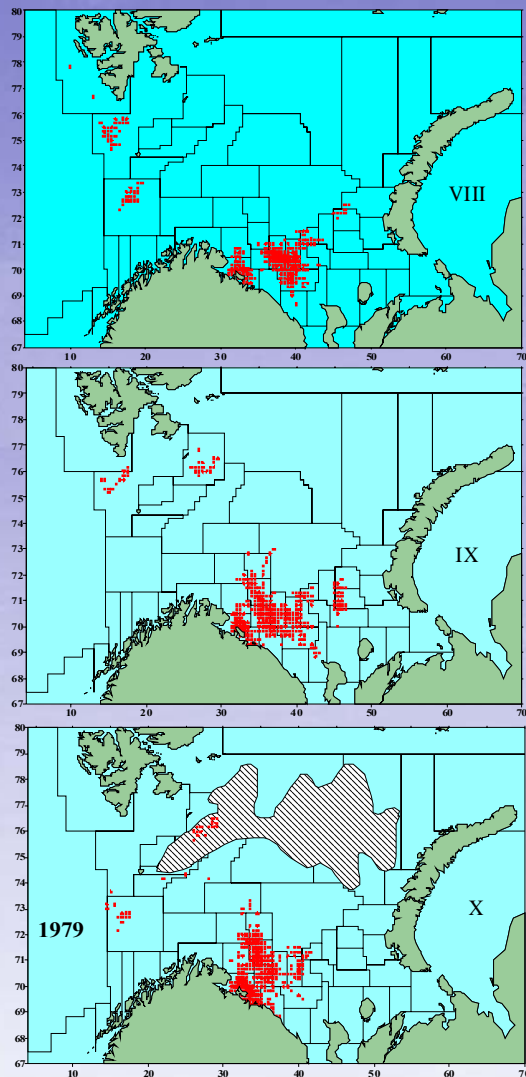


In moderate 1980, in August-September, capelin having migrated northward to 77-78°N fed on euphausiids in the large area from the South Cape Deep to the Perseus Elevation. In 1980, their value by weight was very high: 58% in August, 62-96% in September-October, 89% in November.





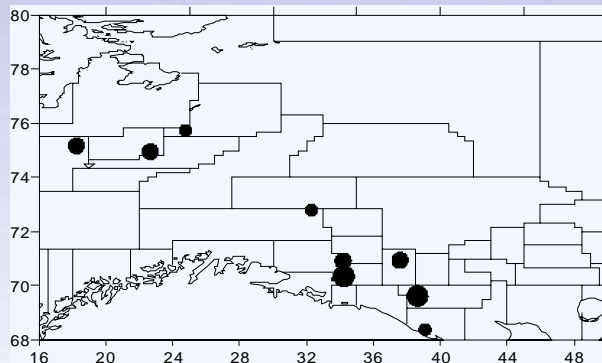
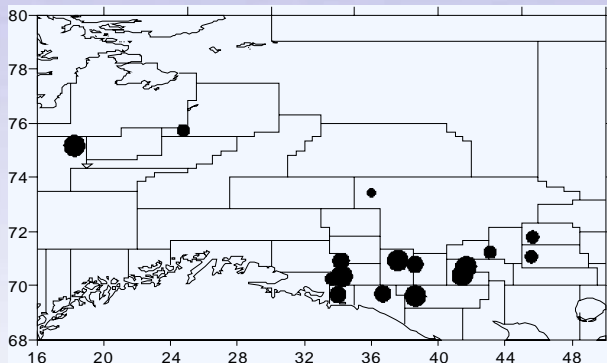
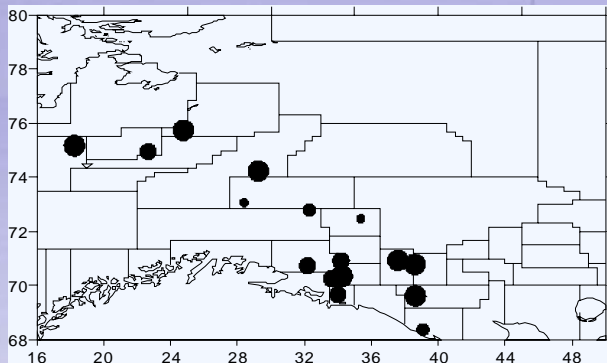
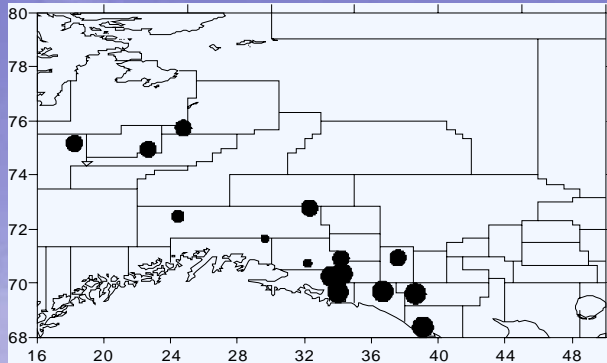
# Distribution of cod (red color) and capelin (shading) aggregations in the Barents Sea in 1979 and 1980



In 1979 and 1980, cod distribution was, to a minor extent, connected with capelin. Alongside with this, taking into consideration that cod small concentration overlapped the capelin ones feeding one can assume that the reason of the limited consumption of capelin was not only inaccessibility for cod because of low temperature.



# Frequency of occurrence (%) euphausiids in cod stomachs in June (a), July (b), August (c) and September (d) 1998

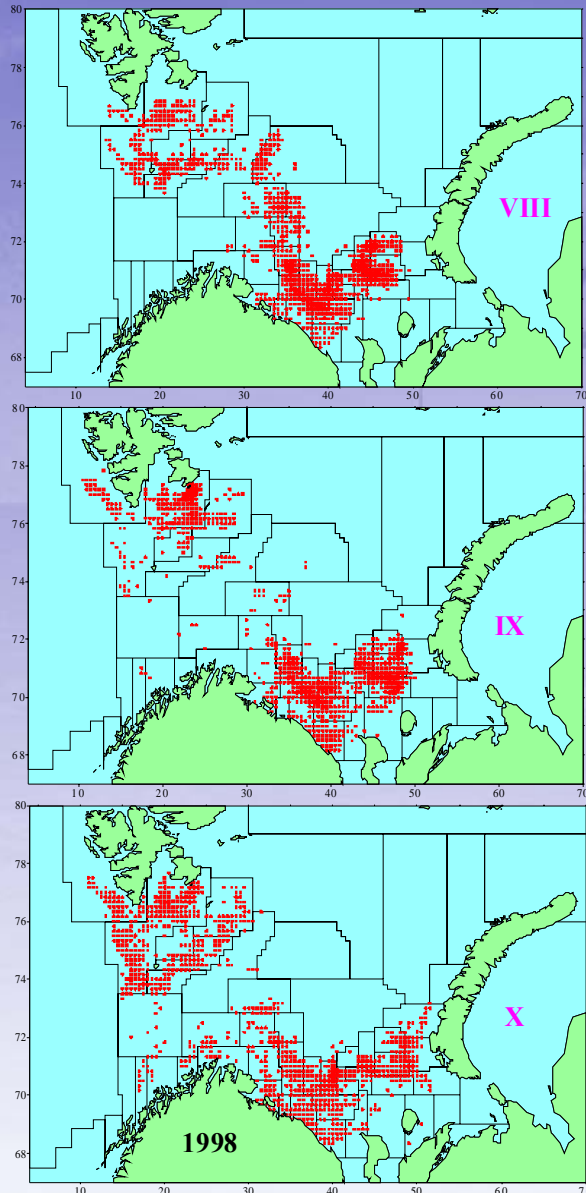


In 1996-1998, cod northeast aggregations distributed more southward, than usually, overlapping the euphausiid ones. In those years, a small increase in capelin abundance was being noticed, however, till August, capelin seldom occurred

in the cod diet, and cod regularly (from April to July) fed on euphausiids



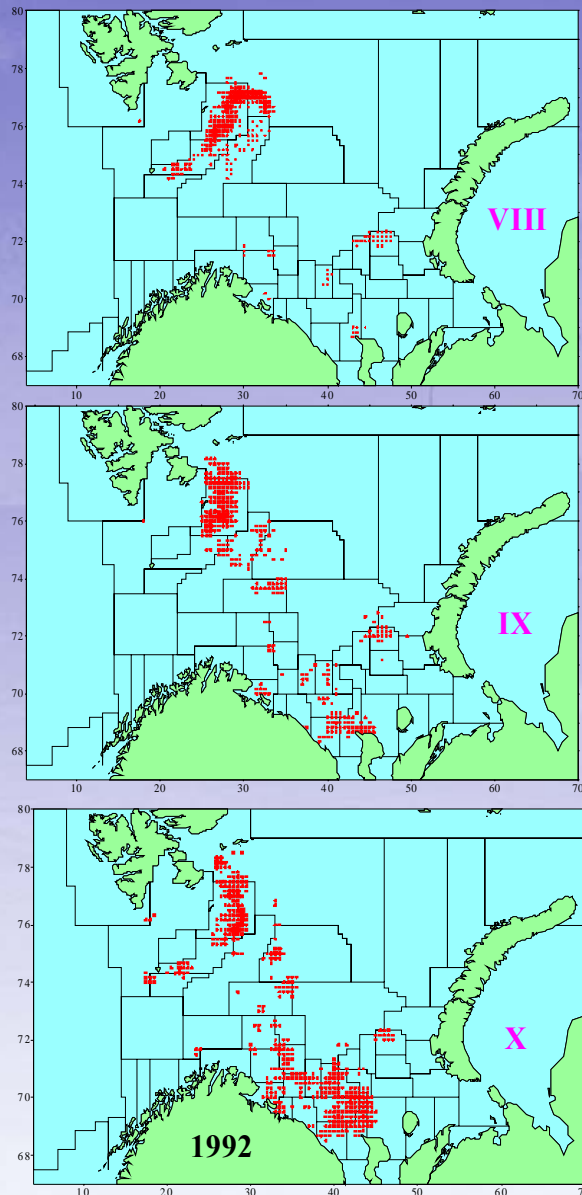
# Distribution of cod aggregations (red color) in the Barents Sea in August-October 1998



The distribution of cod was the most northward in 1998, when its schools reached 77°N in the area of the West Spitsbergen, the southern extremity of the Edge Island, in the South Cape Deep and Hope Area partly overlapping aggregations of feeding capelin which distributed to 79°N.



# Distribution of cod aggregations (red color) in the Barents Sea in August-October 1992

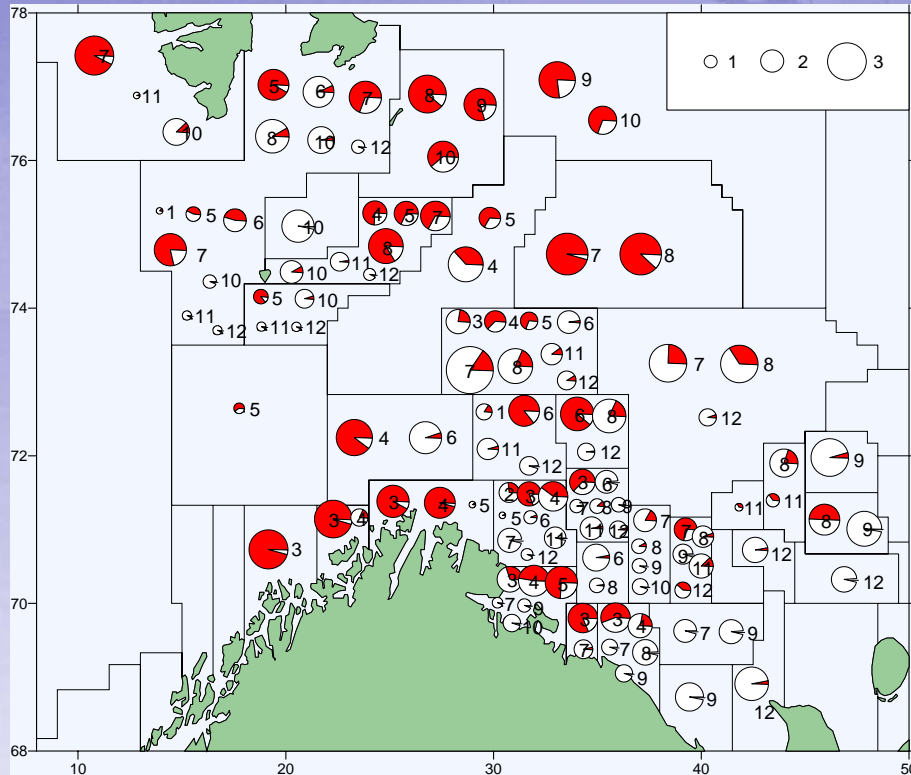


In 1990-1992 cod was characterized by the north distribution. In the Hope Area and Perseus Elevation, large fish reached  $78^{\circ}\text{N}$ - $78^{\circ}30'\text{N}$ . There, feeding areas of cod and capelin overlapped that conditioned a high consumption level of the latter.





# Frequency of occurrence (% , red color) capelin in cod stomachs in the Barents Sea by months 1999 (ciphers show months)

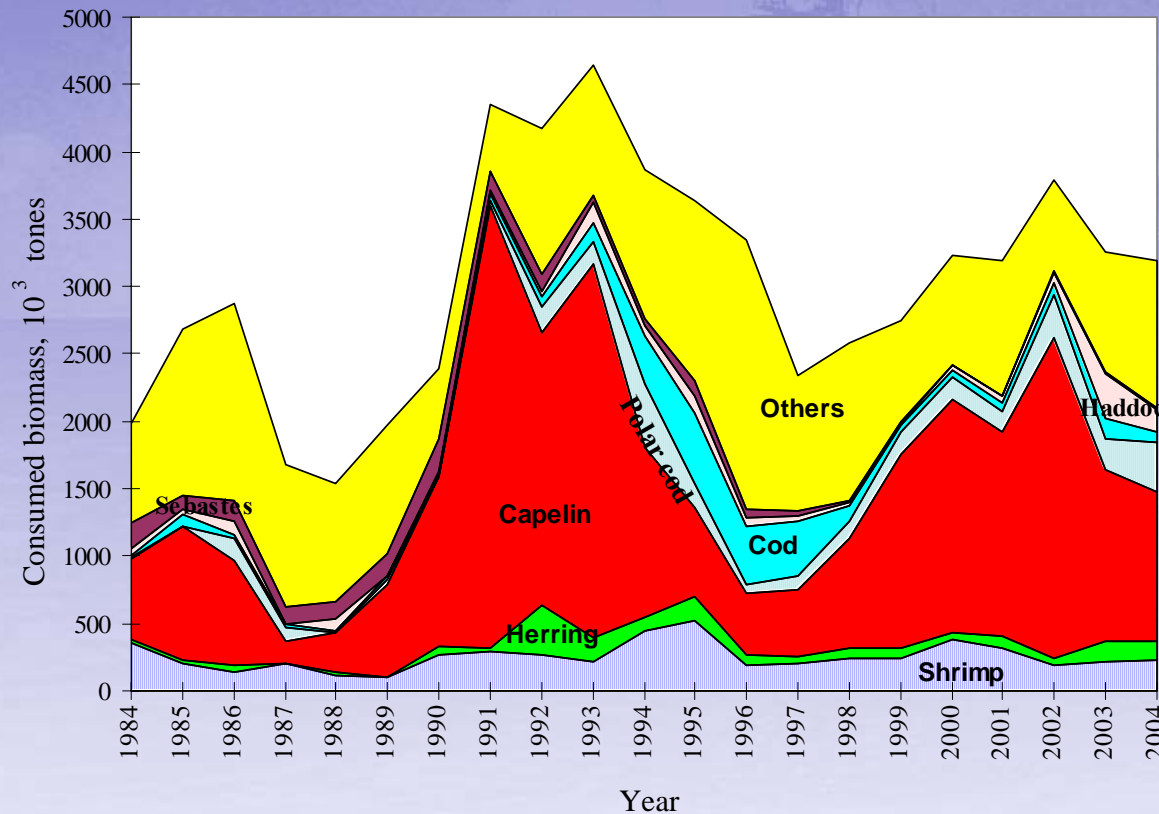


The most favourable conditions of cod feeding were in 1999-2001, when capelin abundance increased. The year of 1999, when cod fed on capelin already in January, was noted in the northwestern wintering years. Intensive capelin feeding was recorded in May-June. Capelin frequency of occurrence reached 65-90% that conditioned its maximal value in the annual feeding – about 60% by weight.





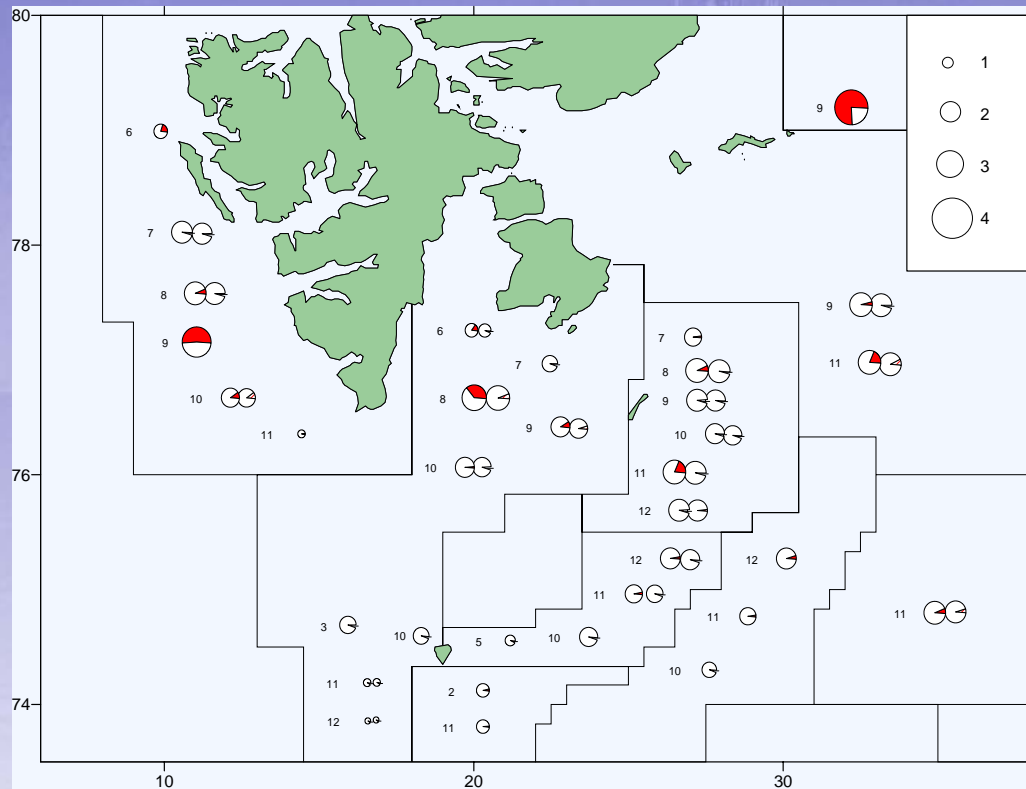
# Food consumption of cod in the Barents Sea in 1984-2004



In 2003-2004, despite the usual reduction in capelin stock, the fish consumption by cod in absolute figures was extremely high in 2003 and 2004 (1263 t and 1101 t, respectively) and was approaching to the level of 1999-2001



# Frequency of occurrence polar cod (red colour) and young polar cod (shading) in cod stomachs in the Barents Sea by months 2001 (ciphers show months)



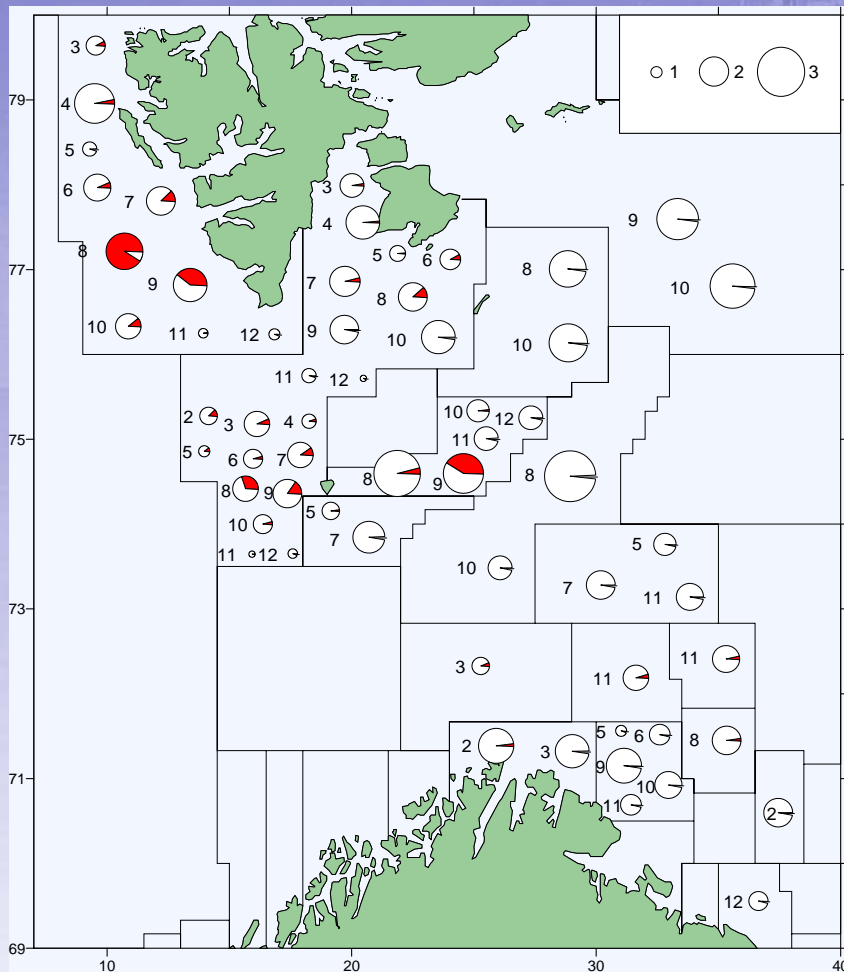
Since 1999-2000, the area of cod feeding on polar cod widened and the adult fish started to be consumed by the cod from the West Spitsbergen to the Perseus Elevation and the Franz Josef Land. In

2004 polar cod practically substituted capelin in the food of cod. In its turn, that might be indicative of food competition strengthening between them in favour of polar cod.



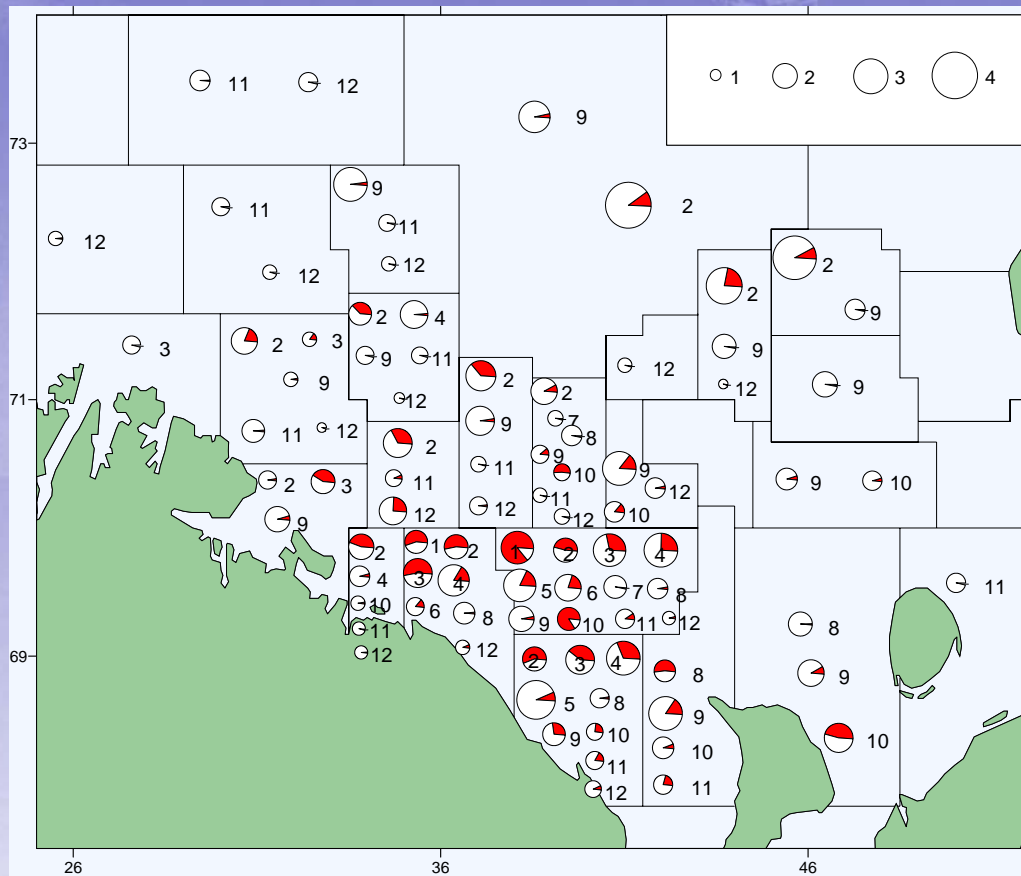
# Frequency of occurrence (red colour) blue whiting in cod stomachs in the Barents Sea by months 2002 (ciphers show months)

- A wide distribution of blue whiting in warm years favours growth of food competition between fish species. In the Bear Island-Spitsbergen area, where to large fish migrate, they, alongside with euphausiids and hyperiids, feed on capelin, polar cod, juvenile cods.
- The blue whiting itself also started to occur significantly more often in cod feeding. The largest area of blue whiting consumption was recorded in 2002, that coincided with the maximal biomass of this fish in the Bear Island-Spitsbergen area (around  $145 \times 10^3 \text{t}$ ) and made up about 10% by weight in the annual diet of cod.





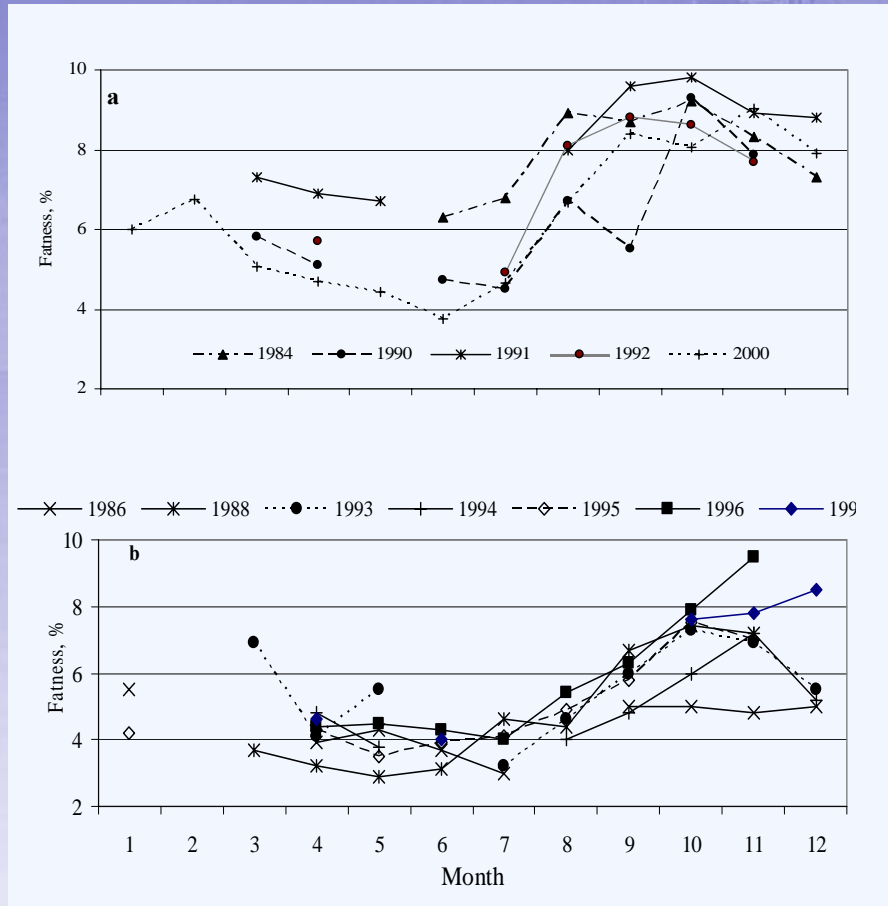
# Frequency of occurrence (red colour) herring in cod stomachs in the Barents Sea by months 2003



Herring doesn't play a considerable part in cod feeding in the Bear Island-Spitsbergen area. Due to the above-mentioned shift of cod wintering borders eastwards, its influence on concentrations of herring wintering in the central, coastal southeastern and even eastern areas strengthened. In the highest degree, it showed itself in 2003



# Seasonal changes in cod fatness with high (a) and low (b) capelin supply



Capelin was characterized by higher calorie content (2 kkal/g in raw weight). According to the significance of capelin in annual dynamics of cod feeding, the two groups of years. The first group included the years with the capelin significance of 15% and more in the cod diet (1984, 1990-1992, 1998-2000). In most cases, after a small reduction in fatness in May-July, its abrupt rise (8-9%) was registered in August-October and the level was high till December. The second group involved the years with the significance of less than 15% (1986-1988, 1993-1997)





# CONCLUSION

- Structural changes in pelagic (plankton, nekton) communities and interspecific relations of the main commercial fishes determined the effectiveness of the Barents Sea ecosystem functioning. From time to time fishery made a significant contribution to the trophodynamics that, on the background of climatic variations led to catastrophic consequences. It is exemplified by the falling out of the Atlanto-Scandian herring, playing a great part in ecosystem and cod feeding, from pelagic fish community for a long period (the late 1960s-early 1980).
- The situation with capelin also turned out dramatically. Cold years (mid-1970s- the early 1980s) conditions were the most favorable for capelin. Good feeding conditions, a high growth and reproduction rates provided big size of capelin stock.
- Cod was provided well with the main food (capelin) and didn't make stretched migrations, concentrated in the western areas. These factors promote the disconnection of feeding areas of cod and capelin, which feed in the north waters, that conditioned a weak press of predators. The lack of main capelin food competitors (juvenile cods) also had a favorable effect on capelin feeding condition. As a result, fatness of both capelin and cod was high.



- Capelin was fished intensively that led to the collapse of its stocks in the mid-1980s. With a low abundance and abrupt reduction of older fish in population, capelin didn't use feeding resources of northern areas. Capelin deficiency resulted low cod feeding and the increase in the consumption of euphausiids and hyperiids, i.e. cod and capelin became food competitors.
- Despite of mass cod feeding on macroplankton, food chain was shortest then usually; the low calorie content of those crustaceans did not compensate fish energy consumption. As a result, cod fatness was low (less then 3%). Only in some periods, with a short-term recovery of capelin abundance, ecosystem came to a normal condition (1990-1992) based on interaction of the key species: euphausiids, copepods – capelin – cod.
- In the warm period (1999-2004) plankton-eater feeding base stabilized due to strengthening the transport of warm-water species euphausiids (and copepods, probably) and their wide distribution in the Barents Sea, as well as the opportunity of fish to use food resources of northern areas.



- Plankton abundance conducted migrations and wide distribution of blue whiting from Norwegian Sea and polar cod from Kara Sea. As a result, abundance of these fishes in the Barents Sea increased. On the other hand in some local areas their feeding areas overlapped (capelin and polar cod, cod and blue whiting) that led to the strengthening of food competition, which was indicated by low fatness of these fishes in some cases.
- Negative consequences of food competition for cod were leveled by its wide distribution in the warm years and high accessibility of capelin and polar cod, as well as of herring, wintering in the southeast and east. The level of consumption of these fishes by cod was rather high, and cod fatness increased. Blue whiting didn't play a significant part in cod feeding, since fish having completely return migration mainly consumed them (November-December). Euphausiids, being consumed by cod mainly, were stabilizing as a food supply of plankton-eaters.



- Capelin, with its high accessibility for cod in the conditions of warm years, it was under a great predation press, which might be confirmed by the level of the fish consumption in that period. Capelin consumption by predators was intensified by fishery that resembled that one in 1993-1995. In contrast with the 1970s, when the predation press was practically absent. At present the influence of predators (of cod, only) is greater than the effect of fishery.



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